

REMARKS/ARGUMENTS

Applicant has carefully studied the Examiner's objections and the cited prior art, and hereby files a new set of claims in which new independent claim 14 corresponds to a combination of former claim 1 and former claim 4. Former claims 2, 3, 5 and 6 are maintained and now dependent on new claim 14. Claim 8 has been amended to more clearly distinguish over the prior art.

The invention relates to a method of acquiring and processing images of a tooth in order to detect dental caries. The method involves lighting a zone of the tooth by alternating pulses of monochromatic light at two different wavelengths, the first wavelength being ultraviolet and selected to excite emission of fluorescence by the mineral part of the tooth and the second wavelength being a visible wavelength. Video means is used to take fluorescence images of the zone lighted by the first wavelength pulses in two wavelength bands, one of which is in a high energy portion and the other of which is in a low energy portion of the emission spectrum, and images of said zone lighted by visible light pulses. At each point of the image, a ratio is computed of the spectral intensity of the emitted fluorescence in said two wavelength bands and this ratio is compared with predetermined values.

The invention as recited in new main claim 14 is neither disclosed nor suggested by the cited prior art. Jung et al. discloses a spectrometer assembly comprising a plurality of optical sensors coupled to a plurality of narrow optical filter elements adapted to define a wide spectral band. The invention may be used in the field of dentistry, for example to help a dentist to match the colors of a patient's teeth and the colors of dental prostheses. A monochromatic UV light may be used to illuminate the tooth (col. 15, lines 33 – 60, as mentioned by the Examiner) in order to excite emission of fluorescence by the tooth. Video means may be used to take images of the lighted zone of the tooth in order to store those images in a database (col. 37, lines 15 – 18), in relation with the corresponding results of spectrometric analyses.

However, the monochromatic UV light, which should be in the range 10 – 380 nm according to the standard definition of UV radiation, is not selected to specifically excite emission of fluorescence by the mineral part of the tooth, which requires a radiation in the range

300 – 370 nm (see page 3 line 24 and page 4 lines 16 – 17 of the present application). In col. 45 lines 14 – 17, Jung does not mention an excitation of fluorescence by the mineral part of the tooth, but explains that the invention helps to distinguish between light that is reflected by the surface of the tooth from light that is scattered deep inside the tooth and then reemitted.

Moreover, the video images of the tooth taken by an intraoral camera are not taken in two wavelength bands, one of which being in a high energy portion and the other of which being in a low energy portion of the emission spectrum. Those video images are not used for photometric analyses, since the only processing applied to them is a “posterization” to show contours of adjacent color boundaries on the surface of the tooth and because other optical analyses are done by an intraoral reflectometer. In col. 45 lines 31 – 39, it is only explained that this prior invention is adapted to quantify optical properties of internal structures of the tooth.

In addition to not being determined in each point of an image of the tooth but in a global manner for the whole tooth, the spectral intensities determined by two filters are only used to provide the corresponding parts of an emission spectrum, but not to compute a ratio adapted to be compared to predetermined values in order to detect the presence of dental caries. Indeed, col. 59 lines 55 – 61 cited by the Examiner do not mention such a ratio but a gain adjustment factor relating to the existence of an intensity peak when the probe of the device is positioned at a certain height of the observed surface. Besides, the tooth is not illuminated by alternating pulses of visible and UV light as in the present patent application.

The “gate array” mentioned in col. 50 lines 45 – 53 of Jung et al. “serves to measure the output frequency and period of each of sensors 616 independently” in order to cover a large spectral band, and this gate array is used as an interface between the sensors and a computer. The timer mentioned here is not used to control illumination means but to sample the output signal of the light to frequency converting sensors 616. Hence, the invention defined by new main claim 14 differs from the invention disclosed by Jung et al. in that:

- the tooth is illuminated by alternating pulses of monochromatic light at two different wavelengths, one ultraviolet and the other visible, the UV light being selected to excite emission of fluorescence by the mineral part of the tooth;

- video images of the tooth are taken in two wavelength bands that are specifically chosen so that the ratio of the intensities in these two bands is highly dependent on the presence of caries (see page 11 line 33 – page 12 line 3), so as to provide a means to detect caries with a very good reliability by comparing said ratio to predetermined values;
- the ratio of intensities is computed for each point of the video images of the tooth so as to localize precisely the presence of caries;
- video images of the tooth are also taken during the illumination at the visible wavelength in order to make the analyzed zone of the tooth apparent for the user.

Therefore, the invention defined by the claims is new and not obvious with respect to Jung et al.

Maxwell *et al.* discloses an “optical technique and device for assessing tooth vitality by use of trans-illumination to detect differentially the relative absence of light absorbed by hemoglobin in circulating blood inside a healthy tooth”. The subject of this document appears to be quite far from the present application, and the essential characteristics of the invention as defined by new main claim 14 cannot be found in this document.

Hibst *et al.* discloses a device for detecting dental caries by illuminating a tooth with a light at a wavelength comprised in the spectral range from 360 to 580 nm to excite emission of fluorescence by the tooth. An image of this emitted fluorescence is formed in two spectral bands, one band ranging from 620 to 720 nm in which the intensity of the fluorescence depends on the presence of caries, the second band ranging from 540 to 560 nm in which the intensity of the fluorescence does not depend on the presence of caries. A ratio of the intensities in these two spectral bands is then computed in a global manner (*i.e.* for the whole image of the tooth, not in each point of it).

The invention defined by amended claim 1 differs from the invention disclosed by Hibst et al. in that:

- the tooth is illuminated by alternating pulses of monochromatic light at two different wavelengths, one ultraviolet being selected to excite emission of fluorescence by the mineral part of the tooth, and the other being visible;

- video means are used to take images of the fluorescence of the lighted zone of the tooth in high energy and low energy spectral bands as well as images of the zone during illumination by the visible light;
 - a ratio of the intensities of the fluorescence returned in the high and low energy spectral bands is computed in each point of the images of the tooth, which allows the practitioner to precisely localize the possible caries, thanks to the images of the tooth in visible light.
- Consequently, the object of amended claim 1 is new and not obvious with respect to this

reference.

Mandelis *et al.* discloses a method and device for detecting dental caries by use of photothermal radiometry and alternating current modulated luminescence, wherein photothermal and luminescent radiations emitted by a tooth are analyzed and compared to reference data. The essential means of new main claim 14, as discussed earlier, cannot be found in this document, which provides a very different way of detecting dental defects. Consequently, the subject of new main claim 14 is new and nonobvious over all the cited prior documents taken separately or in view of one another, and is therefore patentable. Claims 2, 3 and 5 to 13 depend on the independent claims and are therefore allowable with the independent claims.

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It is not believed that extensions of time or fees for net addition of claims are required, beyond those that may otherwise be provided for in documents accompanying this paper. However, in the event that additional extensions of time are necessary to allow consideration of this paper, such extensions are hereby petitioned under 37 CFR § 1.136(a), and any fee required therefore (including fees for net addition of claims) is hereby authorized to be charged to Deposit Account No. 16-0605.

Respectfully submitted,

/Raymond O. Linker, Jr/

Raymond O. Linker, Jr.
Registration No. 26,419

Customer No. 00826
ALSTON & BIRD LLP
Bank of America Plaza
101 South Tryon Street, Suite 4000
Charlotte, NC 28280-4000
Tel Charlotte Office (704) 444-1000
Fax Charlotte Office (704) 444-1111

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